Note on new interesting baryon channels
to measure the photon polarization in $b \to s\gamma$

L. Oliver[1], J.-C. Raynal[1] and R. Sinha[2]

[1] Laboratoire de Physique Théorique[1]

Université de Paris XI, Bâtiment 210, 91405 Orsay Cedex, France

[2] Institute of Mathematical Sciences

CIT Campus, Tharamani, Chennai 600113, India

Abstract

At LHC a large number of b-flavored baryons will be produced. In this note we propose new baryon modes to determine the photon helicity of the penguin transition $b \to s\gamma$. The decay $\Lambda_b \to \Lambda\gamma$ has the drawback that the Λ, being neutral and long-lived, will escape detection most of the time. To overcome this difficulty, transitions of the type $\Lambda_b \to \Lambda^*\gamma$ have been proposed, where Λ^* denotes an excited state decaying strongly within the detector into the clean mode pK^-. The doublet Ξ_b, that decays weakly, has a number of good features. The charged baryon Ξ_b^- will decay into the mode $\Xi^-\gamma$, where the ground state hyperon Ξ^-, although it will decay most of the time outside the detector, can be detected because it is charged. We consider also the decay of Ξ_b into $\Xi^*\gamma$, where a higher mass state Ξ^* can decay strongly within the detector. We point out that the initial transverse polarization of Ξ_b has to be known in all cases. To determine this parameter through the transition $\Xi_b \to J/\Psi\ \Xi$, we distinguish between different cases, and underline that in some situations one needs *theoretical input* on the asymmetry parameter α_{Ξ_b} of the primary decay. *A fortiori* the same considerations apply to the case of the Λ_b.

[1]Unité Mixte de Recherche UMR 8627 - CNRS

1 Introduction

The photon polarization in $b \to s\gamma$ transitions is an important observable in view of detecting possible New Physics (NP). A number of processes have been proposed in the literature as $B_d \to K^*\gamma$ [1] or more generally $B_d \to K\pi\pi\gamma$ [2], the latter involving quasi two-body modes and a continuum. On the other hand, the baryon decay $\Lambda_b \to \Lambda\gamma$ has also been proposed [3][4][5], but it has the important drawback that the very energetic final Λ, at LHC for example, will escape detection most of the time. To overcome this difficulty there has been the proposition [6][7] of decays $\Lambda_b \to \Lambda^*\gamma$, where Λ^* is an excited state decaying of spin $\frac{1}{2}$ or $\frac{3}{2}$, strongly decaying within the detector into pK^-, a very clean signature.

The present note is a very straightforward application of the formalism clearly exposed in the articles by F. Legger and T. Schietinger [6] and G. Hiller et al. [7]. The main formulas that we need can be found in these papers. For completeness and clarity we will recall the main needed ones.

In this paper, instead of excited $I = 0$ baryons considered in [6], we focus on other *ground state* b-flavored baryons, namely the isospin doublet Ξ_b^0 and Ξ_b^-, of spin-parity $\frac{1}{2}^+$, made out of bsu and bsd quarks respectively, that offer, as we will see below, a number of advantages. To our knowledge, these modes have not been considered in the literature as far as the photon helicity measurement in the $b \to s\gamma$ transition is concerned.

The interest of the isospin doublet Ξ_b^0 and Ξ_b^- is that it decays *weakly* with a lifetime of the order of 1.4×10^{-12} sec [8] and therefore one can expect that the decays into the hyperon Ξ's like $\Xi_b \to \Xi\gamma$, where Ξ denotes the ground state of spin-parity $\frac{1}{2}^+$, or $\Xi_b \to \Xi^*\gamma$, where Ξ^* is a higher mass state, will have non-negligible branching ratios. The inclusive semileptonic $\Xi_b \to \ell\nu\Xi + X$ and non-leptonic $\Xi_b \to J/\Psi\Xi$ decays have been already observed [8].

One can consider decays of the type $\Lambda_b \to \Lambda(\to p\pi^-)\gamma$, e.g. $\Xi_b \to \Xi(\to \Lambda\pi)\gamma$. As for the case of the Λ, the final Ξ, being long-lived, will decay most of the time ouside the detector. Of course, one could also examine the decays to strongly decaying resonances, analogous to $\Lambda_b \to \Lambda^*(\to K^-p)\gamma$, as for example $\Xi_b \to \Xi^*(\to \Xi\pi)\gamma$.

In the present paper we want to underline that some radiative decays of the isospin doublet Ξ_b^0 and Ξ_b^- will have nice signatures. The charged baryon Ξ_b^- will

decay into the mode $\Xi^-\gamma$, where ground state $\Xi^-\left(\frac{1}{2}^+\right)$, being charged, can be detected. On the other hand, the neutral mode Ξ_b^0 can decay into resonances $\Xi^{*0}\gamma$, with Ξ^{*0} decaying *strongly* into observable *charged* particles within the detector.

Of course, the number of b-flavored baryons produced at LHC will play an important role. A. Fridman and R. Kinnunen [9] have made an estimation of the number of b-baryons expected in pp collisions at a c.m. energy of ~ 16 TeV and a luminosity $\mathcal{L} = 10^{32}$ cm^{-2} s^{-1}. This can give an idea of the rough number of b-baryons that could be expected at LHC. They find the following number of b-baryons/year (summing over the different isospin states) :

$$N(\Lambda_b)/N(\Sigma_b)/N(\Xi_b) \simeq (1.8 \pm 0.1) \times 10^{10}/(3.6 \pm 0.3) \times 10^9/(2.0 \pm 0.2) \times 10^9 \quad (1)$$

Therefore, even if Λ_b is expected to be produced more abundantly, the Ξ_b baryons will also be produced in great numbers.

There is an important remark to be done at this point. In the heavy quark limit, there are two states made out of bsq quarks (q = u, d), $|\Xi_{b3}>$ and $|\Xi_{b6}>$, corresponding to the two possible $SU(3)$ representations for the light cloud, that has flavor quantum numbers sq (q = u, d), namely $\overline{\mathbf{3}}$ (antisymmetric in flavor, that contains Λ_b and the doublet Ξ_{b3}) and $\mathbf{6}$ (symmetric in flavor, that contains the triplet Σ_b, the doublet Ξ_{b6} and the singlet Ω_b) (see for the case of Ξ_c, p. 1183 of [8]). The physical states made out of bsq (q = u, d) are linear combinations of the heavy quark limit states :

$$|\Xi_b> = \cos\theta_b \, |\Xi_{b3}> + \sin\theta_b \, |\Xi_{b6}> \quad (2)$$

$$|\Xi_b'> = -\sin\theta_b \, |\Xi_{b3}> + \cos\theta_b \, |\Xi_{b6}> \quad (3)$$

where the angle θ_b is subleading in $\frac{1}{m_b}$, of the order of the degree (see for example the discussion in [10] for the case of the couple Σ_c and Σ_c').

Because of Fermi-Dirac statistics, the wave function of $|\Xi_{b3}>$ and $|\Xi_{b6}>$ will be respectively antisymmetric and symmetric in the spin of the valence light quarks. In the quark model, the mass difference between both states is given by the Fermi hyperfine interaction, inversely proportional to the heavy quark mass. The mass difference is then expected to be of the order $M_{\Xi_b'} - M_{\Xi_b} \simeq \frac{m_c}{m_b}(M_{\Sigma_c'} - M_{\Sigma_c}) \simeq 35 \, MeV$.

Unlike the case of the pair Σ_c, Σ'_c, in the case of the b-flavored baryons, only the lowest state Ξ_b, that decays weakly, has been observed. The state Ξ'_c has been seen decaying into $\Xi_c \gamma$, and the same is expected for the analogous b-flavored baryon Ξ'_b.

In the present paper we are concerned by the lowest, weakly decaying, state Ξ_b. From now on we follow very closely the scheme of the paper by F. Legger and T. Schietinger [6], applying their formalism to the decays that are of interest to us in the present paper, $\Xi_b \to \Xi\gamma$ and $\Xi_b \to \Xi^*\gamma$.

In terms of operators at the leading order in α_s

$$O_7 = \frac{em_b}{16\pi^2} \, \overline{s} \, \sigma_{\mu\nu} \, \frac{1+\gamma_5}{2} \, b \, F^{\mu\nu}$$

$$O'_7 = \frac{em_b}{16\pi^2} \, \overline{s} \, \sigma_{\mu\nu} \, \frac{1-\gamma_5}{2} \, b \, F^{\mu\nu} \tag{4}$$

the effective Hamiltonian for photon emission writes

$$\mathcal{H}_{eff} = -4 \, \frac{G_F}{\sqrt{2}} \, V_{ts}^* V_{tb} \, (C_7 O_7 + C'_7 O'_7) \tag{5}$$

In the Standard Model, for zero light quark masses, the photon has a purely left-handed helicity, and the ratio

$$r = \frac{C'_7}{C_7} \tag{6}$$

that measures the amount of right-handed over left-handed helicity photons, would vanish, $r = 0$. If one does not neglect the strange quark mass, in the Standard Model r is of the order of the ratio of quark masses

$$r \simeq \frac{m_s}{m_b} \tag{7}$$

Of course, beyond the Standard Model, the Wilson coefficient C'_7 can have new contributions, and one can get other values for r, of great interest as a signal of possible NP. This is the main purpose of a measurement of the parameter r through the photon polarization.

The photon asymmetry

$$\alpha_\gamma = \frac{P(\gamma_L) - P(\gamma_R)}{P(\gamma_L) + P(\gamma_R)} \tag{8}$$

4

is given, at leading order in α_s, in terms of (6), by the expression

$$\alpha_\gamma = \frac{1 - |r^2|}{1 + |r^2|} \tag{9}$$

We use now the results of the angular momentum calculations of [6], applied to the cases we are interested in.

2   The case $\Xi_b \to \Xi\gamma$

For the decay into the ground state $\frac{1}{2}^+$ $\Xi_b \to \Xi\gamma$ we have the photon angular distribution (formula (10) of [6])

$$\frac{2}{\Gamma} \frac{d\Gamma}{d\cos\theta_\gamma} = 1 - \alpha_\gamma P_{\Xi_b} \cos\theta_\gamma \tag{10}$$

where P_{Ξ_b} is the Ξ_b polarization and θ_γ is the angle between the Ξ_b-spin and the direction of the photon momentum as defined in the Ξ_b rest frame.

The hyperon Ξ is long-lived, decays dominantly into the $\Lambda\pi$ mode, and has a clear signature in its charged mode $\Xi^- \to \Lambda(\to p\pi^-)\pi^-$. However, it is more difficult to detect than the $\Lambda \to p\pi^-$ case in Λ_b radiative decay, since it involves two long-lived particles. We must underline that, even if the secondary decay $\Xi^- \to \Lambda\pi^-$ is not observed within the detector, the mode $\Xi_b^- \to \Xi^-\gamma$ is detectable, since the hyperon Ξ^- is charged.

3   The case $\Xi_b \to \Xi^*\gamma$

Here Ξ^* denotes resonances with flavor quantum numbers ssq (q = u, d). We will distinguish between the ground state $\Xi\left(\frac{3}{2}^+\right)$, of mass ~ 1530 MeV, and higher mass excited states.

3.1   The decay into the ground state $\Xi_b \to \Xi\left(\frac{3}{2}^+\right)\gamma$

In this case one could consider the decay chain

$$\Xi_b^0 \to \Xi^{*0}(\to \Xi^- \pi^+)\gamma \tag{11}$$

where Ξ^* is the ground state $\Xi\left(\frac{3}{2}^+\right)$, that would decay strongly within the detector into the charged particles $\Xi^- \pi^+$.

However, the state $|\Xi_b > (2)$ is very much dominated by the state $|\Xi_{b3} >$, anti-symmetric in flavor, since the mixing angle θ_b is expected to be small $\theta_b \sim \frac{m_c}{m_b}\theta_c$, of the order of 1 degree [10].

In the constituent quark model, the wave function of the decuplet state $|\Xi^* >$ is totally symmetric in flavor and in spin. Therefore, in the picture in which the decay $\Xi_b^0 \to \Xi^{*0}\gamma$ proceeds by the Penguin transition $b \to s\gamma$ and a us pair of light quarks remain as spectators, the overlap between $|\Xi_b >$ and $|\Xi^* >$ will be very small due to the smallness of θ_b. The overlap can be expected to be suppressed by a large factor due to this effect. Therefore, we expect a very small branching ratio for this mode, that probably will not be of much use for our purpose.

Notice that this argument does not follow for the decay into the ground state $\frac{1}{2}^+$ $\Xi_b \to \Xi\gamma$, because the final baryon wave function has a symmetric piece in flavor (and spin), but also another one that is antisymmetric.

3.2 The decay to Ξ resonances of higher mass

One could also consider decays to higher mass resonances, like $\Xi_b \to \Xi\left(\frac{3}{2}^-\right)\gamma$. This resonance has a mass of 1823 MeV and decays strongly into $\Lambda\overline{K}$ or $\Sigma\overline{K}$. The mode $\Lambda\overline{K}$ is dominant, but has the drawback that the Λ is long-lived and will mostly decay outside the detector. The decay $\Sigma\overline{K}$ has a smaller branching ratio, but could be observed in the charged mode $\Sigma^+ K^-$. This case is analogous to the clean proposal $\Lambda_b \to \Lambda^*\gamma \to pK^-\gamma$ of refs. [6][7], but cannot compete with it in number of events.

4 Comment on the observables for the decay into $J = \frac{3}{2}$ resonances

The relevant angular distributions in the decays into $J = \frac{3}{2}$ resonances $\Lambda_b \to \Lambda^*(\to K^- p)\gamma$ or $\Xi_b^0 \to \Xi^{*0}(\to \Xi^- \pi^+)\gamma$, $\Xi_b^0 \to \Xi^{*0}(\to \Sigma^+ K^-)\gamma$ are given by eqs. (15) and

(19) of [6]. Taking as example the case $\Xi_b^0 \to \Xi^{*0}(\to \Xi^- \pi^+)\gamma$,

$$\frac{2}{\Gamma}\frac{d\Gamma}{d\cos\theta_\gamma} = 1 - \alpha_\gamma^{(3/2)} P_{\Xi_b} \cos\theta_\gamma \tag{12}$$

$$\frac{2}{\Gamma}\frac{d\Gamma}{d\cos\theta_\Xi} = \frac{1}{1 - \frac{\alpha_\Xi^{(3/2)}}{3}}\left[1 - \alpha_\Xi^{(3/2)} \cos^2\theta_\Xi\right] \tag{13}$$

where the superindex $3/2$ means that we are dealing with a resonance Ξ^* of spin $\frac{3}{2}$ and θ_Ξ denotes the polar angle between the Ξ^{*0} flight direction and the Ξ^- momentum in the Ξ^{*0} rest frame.

As pointed out in [6], the asymmetry parameters are given by eqs. (18) and (20) of [6] :

$$\alpha_\gamma^{(3/2)} = \frac{1-\eta}{1+\eta}\,\alpha_\gamma \tag{14}$$

$$\alpha_\Xi^{(3/2)} = \frac{\eta - 1}{\eta + \frac{1}{3}} \tag{15}$$

where α_γ is the photon polarization (8) and η is a parameter measuring the relative strength of the modulus squares of the $\lambda_{\Xi^*} = 3/2$ and $\lambda_{\Xi^*} = 1/2$ amplitudes $\mathcal{A}_{\lambda_{\Xi^*},\lambda_\gamma}$, eq. (17) of [6] in the decay $\Xi_b \to \Xi^{*0}\gamma$:

$$\eta = \frac{|\mathcal{A}_{\pm 3/2,\pm 1}|^2}{|A_{\pm 1/2,\pm 1}|^2} \tag{16}$$

Combining (14) and (15) one gets [6] :

$$\alpha_\gamma = \frac{1}{2}\alpha_\gamma^{(3/2)}\left[1 - \frac{3}{\alpha_\Xi^{(3/2)}}\right] \tag{17}$$

Of course, eqs. (14), (15), (17) are useful if η, defined in (16) is different from 1. Very interestingly, G. Hiller et al. [7] have demonstrated in LEET (Large Energy Effective Theory [11]) or, equivalently, in lowest order in SCET (Soft Collinear Effective Theory [12]), that the helicity-3/2 amplitude vanishes :

$$\eta \simeq 0 \tag{18}$$

From (14), in the approximation (18), formula (12) becomes

$$\frac{2}{\Gamma}\frac{d\Gamma}{d\cos\theta_\gamma} \simeq 1 - \alpha_\gamma P_{\Xi_b}\cos\theta_\gamma \tag{19}$$

In all generality, independently of the value of η, it is illuminating to rewrite the observable $\alpha_\gamma^{(3/2)}P_{\Xi_b}$ in (12) in terms of the observable $\alpha_\Xi^{(3/2)}$. One obtains,

$$\frac{2}{\Gamma}\frac{d\Gamma}{d\cos\theta_\gamma} = 1 + \frac{2}{3}\frac{\alpha_\Xi^{(3/2)}}{1 - \frac{\alpha_\Xi^{(3/2)}}{3}}\alpha_\gamma P_{\Xi_b}\cos\theta_\gamma \tag{20}$$

We observe that in both angular distributions for the cases Ξ (10) and Ξ^* (19) or (20) appears the product

$$\alpha_\gamma P_{\Xi_b} \tag{21}$$

Therefore, to determine α_γ in either case we need experimental information on the polarization P_{Ξ_b}. On the other hand, the parameter $\alpha_\Xi^{(3/2)}$ in (20) is an independent observable that can be measured by the angular distribution (13). Of course, this statement applies also to the corresponding Λ_b decays.

5 Comments on Λ_b and Ξ_b polarization

Let us now concentrate on the question of the theoretical estimation or the possibility of measurement of the transverse polarization P_{Ξ_b}. The most studied b-baryon in the literature has been Λ_b. We will make some comments on the Ξ_b case below.

5.1 Summary and comments on the Λ_b case

Let us first summarize the different results or hints in the most studied Λ_b case, based on the papers that we have quoted above. We repeat here the different attemps or guesses indicated in the literature, adding also some personal remarks that we consider important.

(i) Following general arguments in hadronic collisions [13], P_{Λ_b} could be greater than 20%. For P_{Ξ_b} one could guess something of the same order, although the statistics is here smaller, as we see from (1), since a strange quark has to be created.

(ii) From perturbative QCD [14] one gets a quark transversal polarization

$$P_b \propto \alpha_s m_b \tag{22}$$

The b-quark having a rather large mass, one can expect a polarization of $\mathcal{O}(10\%)$, a large fraction of which is transferred to the Λ_b polarization [15]. Intuitively this can be easily understood, since in the heavy quark limit one has $P_{\Lambda_b} = P_b$ [16].

(iii) As studied in detail in [17][18] one could *measure* P_{Λ_b} through the clean decay chain $\Lambda_b \to \Lambda(\to p\pi^-)J/\Psi(\to \ell^+\ell^-)$. Although the primary decay $\Lambda_b \to \Lambda J/\Psi$ violates parity, the Λ decay also violates parity, with known asymmetry parameter α. This provides a sufficient number of observable correlations to determine P_{Λ_b}. The duplication of unknowns from parity violation in the primary decay is compensated by the parity violation of the Λ decay product.

We encounter here the same problem underlined above that the Λ will decay mostly outside the detector. This measurement would be difficult.

We must emphasize however that the branching ratio has already been measured at the Tevatron [8] :

$$\mathrm{BR}^{exp}(\Lambda_b \to \Lambda J/\Psi) = (4.7 \pm 2.8) \times 10^{-6} \tag{23}$$

(iv) On the other hand, integrating over the azimuthal angle, one has the differential decay rate for $\Lambda_b \to \Lambda J/\Psi$ [18]

$$\frac{2}{\Gamma}\frac{d\Gamma}{d\cos\theta} = 1 + \alpha_{\Lambda_b} P_{\Lambda_b} \cos\theta \tag{24}$$

where θ is the zenithal angle of the hyperon Λ in the Λ_b rest frame, and α_{Λ_b} is the *parity-violating* helicity asymmetry of the decay $\Lambda_b \to \Lambda J/\Psi$

$$\alpha_{\Lambda_b} = \frac{|\mathcal{M}_{\Lambda_b}(+\frac{1}{2})|^2 - |\mathcal{M}_{\Lambda_b}(-\frac{1}{2})|^2}{|\mathcal{M}_{\Lambda_b}(+\frac{1}{2})|^2 + |\mathcal{M}_{\Lambda_b}(-\frac{1}{2})|^2} \tag{25}$$

Theoretical calculations of this asymmetry within the factorization hypothesis have been performed [18]. These calculations make use of the form factors appearing in the amplitude

$$< \Lambda|\bar{s}\gamma_\mu(1-\gamma_5)b|\Lambda_b > = \bar{u}_\Lambda \left\{ \left[F_1(q^2) + \not{p}F_2(q^2) \right] \gamma_\mu(1-\gamma_5) \right\} u_{\Lambda_b} \tag{26}$$

9

$\left(v = \frac{P_{\Lambda_b}}{M_{\Lambda_b}}\right)$ estimated using QCD Sum Rules and HQET [19]. This leads, within factorization, to the theoretical estimate for the asymmetry parameter α_{Λ_b} (25),

$$\alpha_{\Lambda_b} \simeq 80\% \tag{27}$$

pointing to a realistic possibility for the measurement of the $\cos\theta$ term in (24), and therefore to a possible estimate of P_{Λ_b}.

In [20] it is underlined that the estimation of the branching ratio using factorization $\mathrm{BR}^{fact}(\Lambda_b \to \Lambda J/\Psi) = 3.1 \times 10^{-6}$ is in agreement, within errors, with the present experimental result (23). This is encouraging, and since in the decay $\Lambda_b \to \Lambda J/\Psi$ one is dealing with a heavy hadron Λ_b as initial state, the production of a light hadron Λ and the emission of a meson J/Ψ made out of a pair of quarks of identical mass, the estimation of its amplitude by factorization [18][20] could be considered the lowest order within QCD Factorization [21]. Although difficult, one could in principle undertake the task of improving the factorization result for the amplitudes $\Lambda_b \to \Lambda J/\Psi$, and therefore for the polarization (27), and control its hadronic uncertainties by using a theoretical scheme such as QCD Factorization.

(v) In order to try to have information on the Λ_b polarization, one could consider the non-leptonic decay $\Lambda_b \to \Lambda^* J/\Psi$, parallel to the promising Penguin mode [6][7] $\Lambda_b \to \Lambda^* \gamma$, where Λ^* denotes an excited state decaying strongly within the detector into the clean mode pK^-. The primary decay $\Lambda_b \to \Lambda^* J/\Psi$ violates parity, but the decay of the Λ^* conserves parity. Therefore, one is not here in the situation of determining experimentally, by angular correlations, the corresponding parity-violation asymmetry parameter (or parameters) $\alpha^*_{\Lambda_b}$ (different in the decay $\Lambda_b \to \Lambda^* J/\Psi$ considered here than in the case $\Lambda_b \to \Lambda J/\Psi$), and determine in a model-independent way the crucial Λ_b polarization, the main unknown of the problem. One is forced also here to introduce some theory-dependent input on the primary decay in order to have an estimate of the parity-violating asymmetry and therefore of the Λ_b polarization.

However, even if we do not expect to have enough information to determine the Λ_b polarization in this case, a further study of the angular correlations in the decay chain $\Lambda_b \to \Lambda^*(\to pK^-)J/\Psi(\to \ell^+\ell^-)$ (where Λ^* is an excited state of spin $\frac{3}{2}$) could be worth to be undertaken.

5.2   Comments on Ξ_b

Let us now make some comments on the polarization of Ξ_b.

In [17], the possibility of measuring the Ξ_b^0 polarization is proposed through the decay chain $\Xi_b^0 \to \Lambda(\to p\pi^-)J/\Psi(\to \ell^+\ell^-)$. However, as pointed out already in [17] the decay $\Xi_b^0 \to \Lambda J/\Psi$ proceeds through the Cabibbo suppressed quark decay $b \to dc\bar{c}$ as compared to the Cabibbo-allowed decay $b \to sc\bar{c}$ that governs $\Lambda_b \to \Lambda J/\Psi$. Notice that the Cabibbo-suppressed decay $\Xi_b^0 \to \Lambda J/\Psi$ is different from the ones $\Xi_b^0 \to \Xi J/\Psi$ or $\Xi_b^0 \to \Xi^* J/\Psi$ on which we are interested here.

Following what we have learned from the Λ_b in the preceding Subsection concerning points (i)-(v), the same comments apply to $\Xi_b^0 \to \Xi J/\Psi$ or $\Xi_b^0 \to \Xi^* J/\Psi$.

As pointed out above, the equivalent decay to (iii) to measure the Ξ_b polarization would be $\Xi_b \to \Xi(\to \Lambda\pi)J/\Psi(\to \ell^+\ell^-)$ that, for the charged case Ξ_b^- it will have a very clean signature $\Xi^- \to \Lambda(\to p\pi^-)\pi^-$, although hardly observable within the detector.

The comments (iv) and (v) apply respectively to the decays $\Xi_b \to \Xi J/\Psi$ and $\Xi_b \to \Xi^* J/\Psi$. There is already preliminary data on the first mode, and it could be very interesting to have experimental information on both. We must underline that the comment (v) applies to the example of the decay chain $\Xi_b^0 \to \Xi^{*0}\left(\frac{3}{2}^-\right)(\to \Sigma^+ K^-)J/\Psi(\to \ell^+\ell^-)$, because the secondary decays conserve parity.

6   Conclusion

To conclude, in the present paper we have investigated the possibility of having information on the photon polarization of the Penguin transition $b \to s\gamma$ through the weak decays of the b-flavored baryon Ξ_b. We have made extensive use of work done in the literature for the case of the Λ_b. We consider the decays into ground state baryons of the octet $\Xi_b^- \to \Xi^-\left(\frac{1}{2}^+\right)\gamma$ and into $\Xi_b^0 \to \Xi^{*0}\gamma$, where the resonances Ξ^{*0} can decay strongly into charged particles within the dectector. We emphasize the importance of having information on the initial Ξ_b (or Λ_b) polarization, and examine, case by case, which kind of theoretical input is necessary to arrive to the main goal, the estimation of the photon polarization.

Acknowledgements

References

[1] D. Atwood, M. Gronau and A. Soni, hep-ph/9704272, Phys. Rev. Lett. **79**, 185 (1997).

[2] M. Gronau, Y. Grossman, D. Pirjol and A. Ryd, Phys. Rev. Lett. **88**, 051802 (2002); M. Gronau and D. Pirjol, Phys. Rev. D **66**, 054008 (2002).

[3] M. Gremm, F. Krüger and L.M. Sehgal, Phys. Lett. B **355**, 579 (1995).

[4] T. Mannel and S. Recksiegel, Acta Phys. Pol. B **28**, 2489 (1997); T. Mannel and S. Recksiegel, J. Phys. G : Nucl. Part. Phys. **24**, 979 (1998).

[5] G. Hiller and A. Kagan, Phys. Rev. D **65**, 074038 (2002).

[6] F. Legger and T. Schietinger, hep-ph/0605245, Phys. Lett. B **645**, 204 (2007), Erratum-ibid. B **647**, 527 (2007).

[7] G. Hiller, M. Knecht, F. Legger and T. Schietinger, hep-ph/0702191, Phys. Lett. B **649**, 152 (2007).

[8] Review of Particle Physics (Particle Data Group), Phys. Lett. B **667**, 1 (2008).

[9] A. Fridman and R. Kinnunen, CERN-PPE/93-61, Contribution to the 5th International Symposium on Heavy Flavor Physics, Montréal, July 1993.

[10] G. Glenn Boyd, Ming Lu and M.J. Savage, hep-ph/961244, Phys. Rev. **D55**, 5474 (1997).

[11] J. Charles, A. Le Yaouanc, L. Oliver, O. Pène and J.-C. Raynal, Phys Rev. D **60**, 014001 (1999).

[12] C.W. Bauer, S. Fleming, D. Pirjol and I.W. Stewart, Phys Rev. D **63**, 114020 (2001); M. Beneke, A.P. Chapovsky, M. Diehl and T. Feldmann, Nucl. Phys. B **643**, 431 (2002).

[13] E. Leader, *Spin in Particle Physics*, Cambridge University Press.

[14] W.G.D. Dharmaratna and G.R. Goldstein, Phys. Rev. D **53**, 1073 (1996).

[15] A.F. Falk and M.E. Peskin, Phys. Rev. D **49**, 3320 (1996).

[16] T. Mannel and G.A. Schuler, Phys. Lett. B **279**, 194 (1992).

[17] J. Hřivnáč, R. Lednický and M. Smižanská, hep-ph/9405231, J. Phys. G : Nucl. Part. Phys. **21**, 629 (1995).

[18] Z.J. Ajaltouni, E. Conte and O. Leitner, hep-ph/0412116, Phys. Lett. B **614**, 165 (2005); hep-ph/0412131, presented at 10th International Conference on Structure of Baryons (Baryons 2004), Palaiseau, France, October 2004, Nucl. Phys. A **755**, 435 (2005).

[19] C.S. Huang and H.G. Yan, Phys. Rev. D **59**, 114022 (1999) [Erratum-ibid. D **61**, 039901 (2000).

[20] O. Leitner, Z.J. Ajaltouni and E. Conte, hep-ph/0602043.

[21] M. Beneke, G. Buchalla, M. Neubert and C.T. Sachrajda, hep-ph/0006124, Nucl. Phys. B **591**, 313 (2000).